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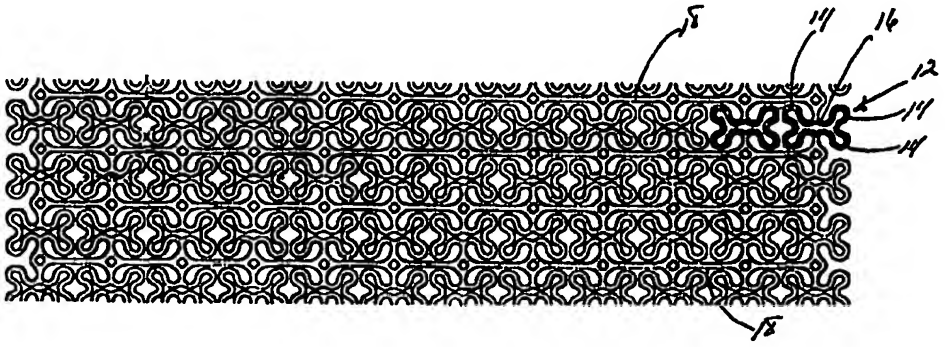

(57) Abstract

Improved stent configurations exhibiting limited recoil, resistance to compression and improved longitudinal flexibility.

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IMPROVED STENT CONFIGURATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to stents of improved configuration.

2. Brief Description of the Prior Art

Stents are radially expandable endoprosthesis which are typically intravascular implants capable of being implanted transluminally and enlarged radially after being introduced percutaneously. They have also been implanted in urinary tracts and bile ducts. They are used to reinforce body vessels and to prevent restenosis following angioplasty in the vascular system. They may be self-expanding or expanded by an internal radial force, such as when mounted on a balloon.

In the past, stents have been generally tubular but have been composed of many configurations and have been made of many materials, including metals and plastic. Ordinary metals such as stainless steel have been used as have shape memory metals such as Nitinol and the like. Stents have also been made of biodegradable plastic materials. Such stents have been formed from wire, tube stock, etc.

SUMMARY OF THE INVENTION

This invention provides new configurations of the cells making up stents which may be adapted to all of the various types of prior art stents described above and/or known previously in the art. There are numerous advantages to the new configurations. The configurations of the invention limit recoil and add resistance to compression for an expanded stent, among other things. Other configurations than cylindrical are contemplated, e.g., square, triangular octagonal, etc. The stents of this invention are longitudinally flexible and expandable.

Brief Description of the Figures

Figure 1 is a flat plan view of an embodiment of the stent configuration of the invention in the unexpanded condition;

Figure 1a is a fragmentary plan similar to Figure 1 showing a staggered arrangement of the cells making up a stent;

Figures 1b and 1c show cells similar to Figure 1 and 1a in different arrangements and with differing interconnection;

Figure 2 is an end view of a stent of Figure 1 according to the invention in its normal tubular unexpanded condition;

Figure 3 is a detail view of a portion of Figure 1, as indicated;

Figure 4 is a view of the stent of Figures 1 and 2 expanded on a balloon;

Figure 5 is another stent embodiment of the invention similar in view to Figure 1 showing the flat plan of the stent in the unexpanded configuration;

Figure 6 is a detail view of a portion of Figure 5, as indicated;

Figure 7 is a showing of the stent of Figure 4 expanded on a balloon;

Figure 8 is a flat plan similar to Figures 1 and 5 showing another stent embodiment in the unexpanded condition;

Figure 8a is a plan view in fragment showing a variation of the cell configuration shown in Figure 8;

Figure 9 is a detail view of a portion of Figure 8, as indicated;

Figure 10 is a showing of the stent of Figure 8 expanded on a balloon;

Figure 11 is a flat plan similar to Figures 1, 5, and 8 showing yet another stent embodiment in the unexpanded condition;

Figure 12 is a detail view of a portion of Figure 11, as indicated;

Figure 13 is a view of the stent of Figure 11 on an unexpanded balloon demonstrating its flexibility in the unexpanded condition;

Figure 14 is a showing of the stent of Figure 11 expanded on a balloon;

Figure 15 is a flat plan similar to Figures 1, 5, 8, and 11 showing yet another stent embodiment in the unexpanded condition;

Figure 16 is a detail view of a portion of Figure 15, as indicated;

Figure 17 is a showing of the stent of Figure 15 expanded on a balloon;

Figure 18 is a flat plan similar to Figures 1, 5, 8, 11 and 15 showing still another stent embodiment in the unexpanded condition;

Figure 19 is a detail view of a portion of Figure 18, as indicated;

Figure 20 is a flat plan view similar to Figures 1, 5, 8, 11, 15 and 18 showing yet another stent embodiment in the unexpanded condition;

Figure 21 is a detail view of a portion of Figure 20, and

Figure 22 is a flat plan view of another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of a generally cylindrical stent 10 according to the invention is illustrated in Figures 1-4. It comprises a metal tube as shown in Figures 2 and 4, such as nitinol or stainless steel preferably, which has been etched or preferably laser cut to the configuration shown in the flat plan view of Figure 1. An enlarged detail of Figure 1 is shown in Figure 3. The configuration is made up of a series of curvilinear expansion cell elements generally indicated at 12 (see darkened example in Figure 3 for clarity) having relatively wide end portions 14 joined by relatively narrow center portions 16. Cells 12 are arranged longitudinally as shown in Figure 1 end to end with respect to the longitudinal axis of the stent 10 and in substantially parallel rows as also shown in Figure 1. A plurality of longitudinally extending elongate support members 18 are included, one each being disposed between adjacent rows of cells 12. Also, a plurality of circumferentially extending support members 19, preferably substantially normal to support members 18 are also positioned between the rows of cells 12 to intersect portions of the support members 18 and to interconnect them to the narrow center portions 16 of cells 12. As can be seen in Figure 1a, cells 12 may also be arranged in a staggered arrangement. Figures 1b and 1c demonstrate different arrangements and interconnections for cells 12.

When the stent is expanded, as shown in Figure 4, on a balloon 20 the cells 12 take on a new configuration as shown, the members making up the stent being indicated by the same numbers as used in Figure 1 and Figure 3. Again, one cell is shown darkened for clarity.

Referring now to Figures 5-7, another stent embodiment generally indicated at 22 of the invention is shown. In this embodiment, as seen in Figures 5 and 6, expansion cells 24, best seen in the detail of Figure 6 and indicated by darkened portion, have relatively wide end portions 26, best seen in Figure 6, and narrow center portions 28 and are arranged end to end in longitudinal rows as

described with respect to the first embodiment. Adjacent end portions 26 are interconnected by pairs of longitudinal support members in the form of segments 30 which have curved end portions 32. Circumferential extending segments 34 extend between rows of cells 24 to interconnect the narrow center portions 28.

Upon radial expansion of the stent, as on a balloon 20 for example, its configuration changes by deformation force in the directions shown by the arrows in Figure 6 to that configuration shown in Figure 7. The elements indicated in Figure 7 are identified by the same numbers indicated for similar elements in Figures 5 and 6.

Figures 20 and 21 show a configuration somewhat similar to that of Figures 5-7 but without interconnecting elements 28.

Referring now to Figures 8-10, another stent embodiment of the invention is shown and generally indicated at 40. Again, as seen in Figures 8 and 9, expansion cells 42 (example darkened for clarity) have relatively wide end portions 44 and narrow center portions 46. The end portions include inwardly extending loop portions 48. Cells 42 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 44 are interconnected by pairs of longitudinal support member segments 50 which have curved end portions 52. Circumferentially extending segments 54 extend between rows of cells 42 to interconnect the narrow center portions 46 of the cells. Figure 8a shows a variation in shape for cells 42.

Upon radial expansion of the stent upon a balloon 20, the configuration changes to that shown in Figure 10. The arrows show the direction of force of deformation upon expansion.

Referring now to Figures 11 and 12, still another embodiment of a stent 60 is shown. Again, as shown in Figures 11 and 12, expansion cells 62 (example darkened for clarity) have relatively wide end portions 64 having a slight inward bend 65 to them and narrow center portions 66. Cells 62 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 64 are interconnected by pairs of longitudinal support member segments 68 which have curved end portions 70. Circumferentially extending segments 72 extend between rows of cells 62 to interconnect the narrow center portions 66 of the cells.

Reference to Figure 13 will show the inherent flexibility of the stents of this invention.

Upon radial expansion of the stent upon a balloon 20, the configuration changes to that shown in Figure 14.

Referring now to Figures 15 and 16, yet another embodiment of a stent 80 is shown in a configuration quite similar to that of Figures 11-14 but with an added circumferentially extending structural element 81. Again, as best seen in Figure 16, expansion cells 82 (examples darkened for clarity) have relatively wide end portions 84 having a slight inward bend 85 to them and narrow center portions 86. Cells 82 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 84 are interconnected by pairs of longitudinal support member segments 88 which have curved end portions 90. Circumferentially extending segments 92 extend between rows of cells 82 to interconnect the narrow center portions 86 of the cells. Circumferentially extending segments 81 interconnect pairs of support member segments 88.

Upon radial expansion of the stent on a balloon 20, the configuration changes to that shown in Figure 17.

Referring now to Figures 18 and 19, still another embodiment of a stent configuration 100 is shown. As before this embodiment is similar to that of Figures 11-12 except that the circumferentially extending segments 101 are arranged differently than those identified in Figures 11-12 as 72. In this embodiment the circumferentially extending members 101 extend between the adjacent ends of adjacent cells 103 (examples darkened for clarity) to interconnect the top of one end to the bottom of the adjacent end and the members 101 have a slight curve or bend 105 in their length. The other members are all similarly numbered as in the preceding Figures.

Figure 22 shows yet another embodiment of a stent comprised of cells 120 having interconnecting circumferential extending members 122. The cells have common sides or end members 124 and are arranged in groups to form bands 126 which are interconnected by joined cells 128.

While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments of the invention. This description is an exemplification of the principles of the invention and is not intended to limit the invention to the particular embodiments illustrated.

The above Examples and disclosure are intended to be illustrative and not exhaustive. These examples and description will suggest many variations and alternatives to one of ordinary skill in this art. All these alternatives and variations are intended to be included within the scope of the attached claims. Those familiar with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be encompassed by the claims attached hereto.

What is claimed is as follows:

1. A stent of generally cylindrical shape made up of a plurality of regularly arranged curvilinear bodies of same shape providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion and being arranged longitudinally in rows with respect to the longitudinal axis of the stent.

2. The stent of claim 1 wherein the curvilinear bodies are also arranged in substantially parallel longitudinal rows end to end and there is included;

a plurality of longitudinal support members positioned between the longitudinal rows of cells, and

a plurality of circumferentially extending connecting members substantially normal to the support members and interconnecting them to the narrow center portions of the cells.

3. The stent of claim 1 wherein the rows of cells are substantially parallel and the cells are in alignment circumferentially.

4. The stent of claim 3 wherein the cells are staggered circumferentially.

5. A stent of generally cylindrical shape made up of

a plurality of curvilinear bodies providing closed expansion cells, the cells being formed of relatively wide end portions and narrow center portions and being arranged in longitudinal rows around the periphery of the stent and end to end in each row;

paired longitudinal connecting members connecting the ends of adjacent cells, and

circumferentially extending members extending between cells of adjacent rows and interconnecting the cells at the narrow portions.

6. The stent of claim 5 including members which extend between adjacent cell ends interconnecting the top of one cell end to the bottom of another.

7. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies of same shape providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion and being arranged longitudinally with respect to the longitudinal axis of the stent.

8. The stent of claim 7 wherein the bodies are also arranged in substantially parallel longitudinal rows end to end.

9. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion.

AMENDED CLAIMS

[received by the International Bureau on 25 March 1999 (25.03.99);
original claims 1,2 and 5 amended; original claims 7-9 replaced by new claims 7-10
remaining claims unchanged (2 pages)]

What is claimed is as follows:

1. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion, the cells arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, longitudinally adjacent cells interconnected by connection members.

2. The stent of claim 1 wherein the longitudinal rows are substantially parallel , the stent further comprising

a plurality of longitudinal extending elongate support members, adjacent longitudinal rows of cells joined by at least one elongate support member, and

a plurality of circumferentially extending connecting members substantially normal to the support members and interconnecting the support members to the narrow center portions of the cells.

3. The stent of claim 1 wherein the rows of cells are substantially parallel and the cells are in alignment circumferentially.

4. The stent of claim 3 wherein the cells are staggered circumferentially.

5. A stent of generally cylindrical shape comprising of a plurality of curvilinear bodies providing closed expansion cells, the cells being formed of relatively wide end portions and relatively narrow center portions and being arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent;

paired longitudinally connecting members connecting the ends of adjacent cells, and

circumferentially extending members extending between cells of adjacent rows and interconnecting the cells at the narrow portions.

6. The stent of claim 5 including members which extend between adjacent cell ends interconnecting the top of one cell end to the bottom of another.

7. The stent of claim 1 wherein the relatively wide end dimensions are further characterized as being substantially identical to each other.

8. The stent of claim 1 wherein the cells are symmetrical in overall shape.

9. A stent of generally cylindrical shape and having a longitudinal axis and a circumference, the stent comprised of a plurality of regularly arranged interconnected curvilinear bodies individual closed expansion cells, the cells having

relatively wide end portions joined by a relatively narrow center portion, some of the cells arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, and some of the cells arranged circumferentially in circumferential rows with respect to the circumference of the stent.

10. A stent of generally cylindrical shape and having a longitudinal axis comprised of a plurality of bands which are made up of a plurality of regularly arranged interconnected curvilinear bodies of same shape providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion and being arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, the bands being interconnected by the curvilinear bodies shared between certain expansion cells located on adjacent edges of the bands, the certain cells being less than the number of cells which make up the band edges.

Fig.1

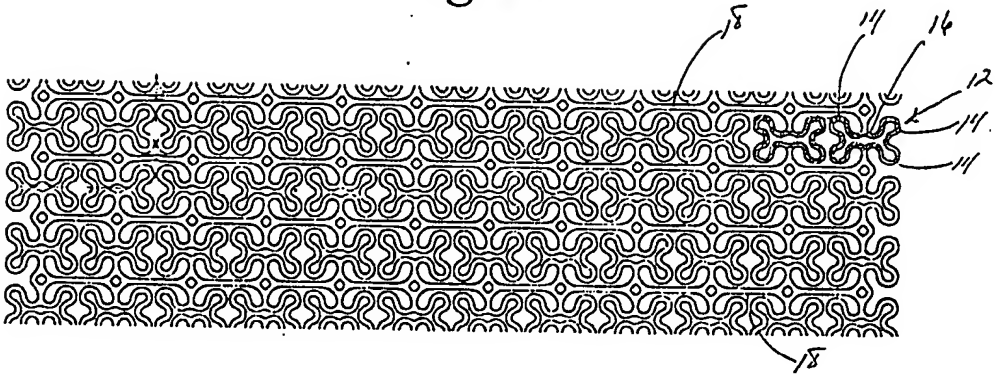


Fig.2

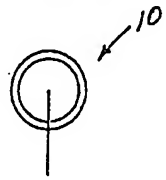
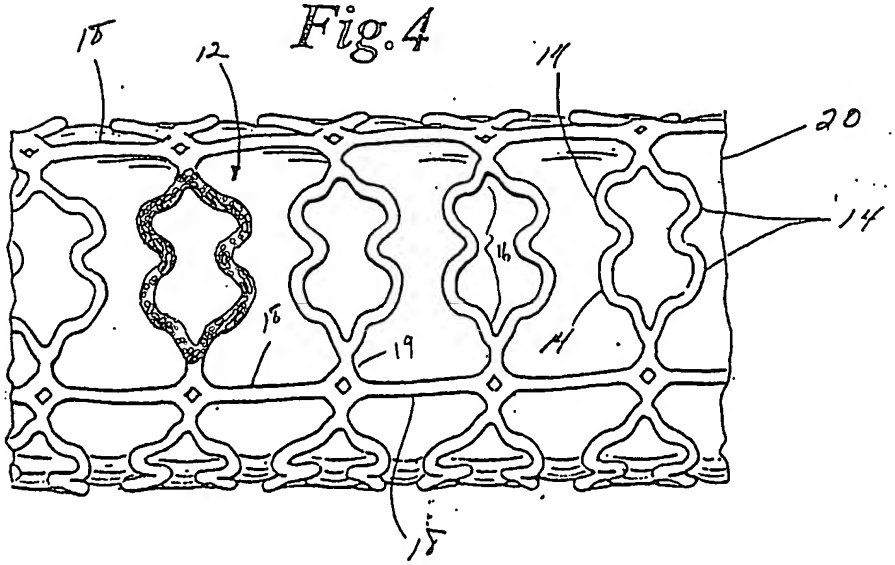


Fig.3

Fig.4



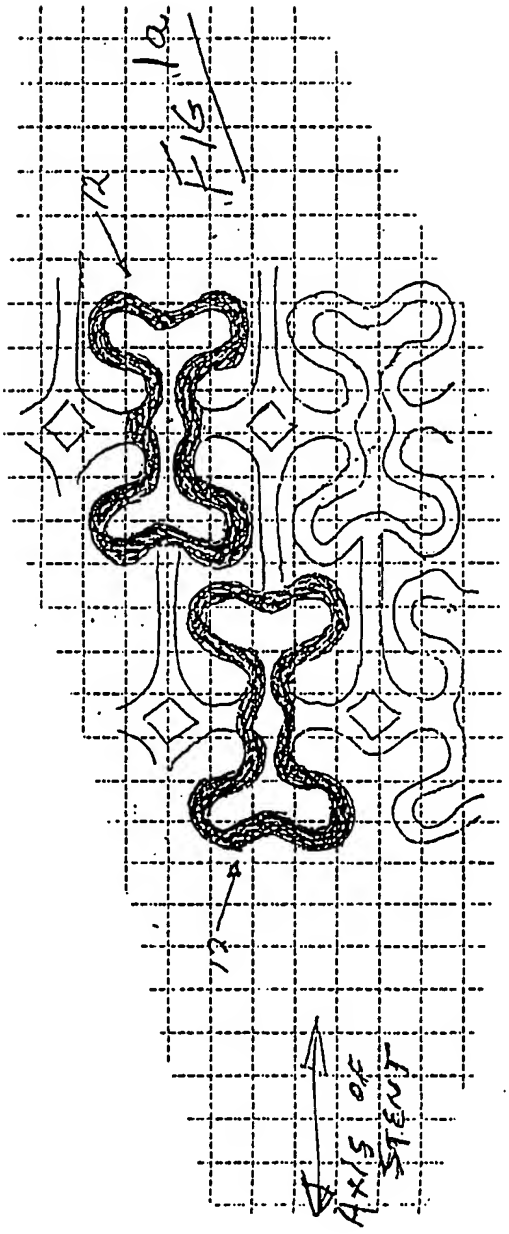

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FIG 1
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14
AXIS OF STENT

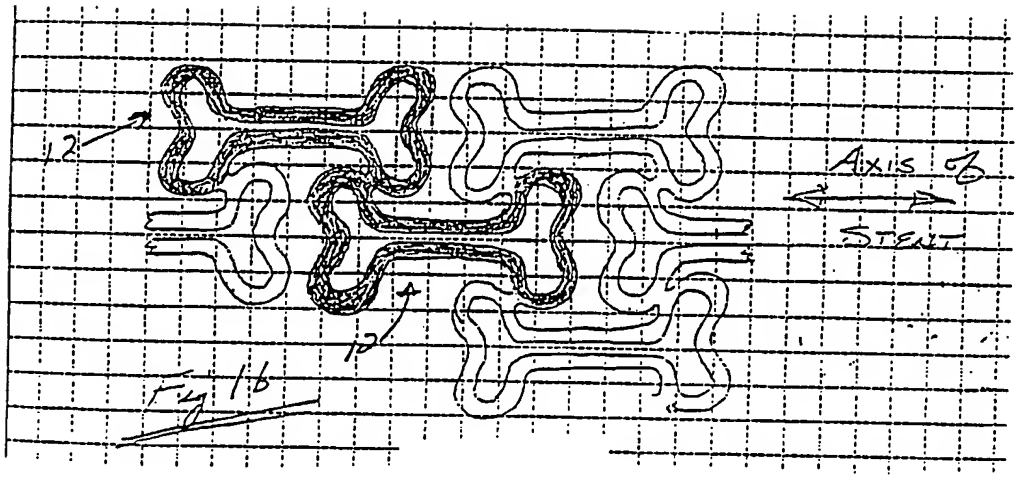


Fig 1b

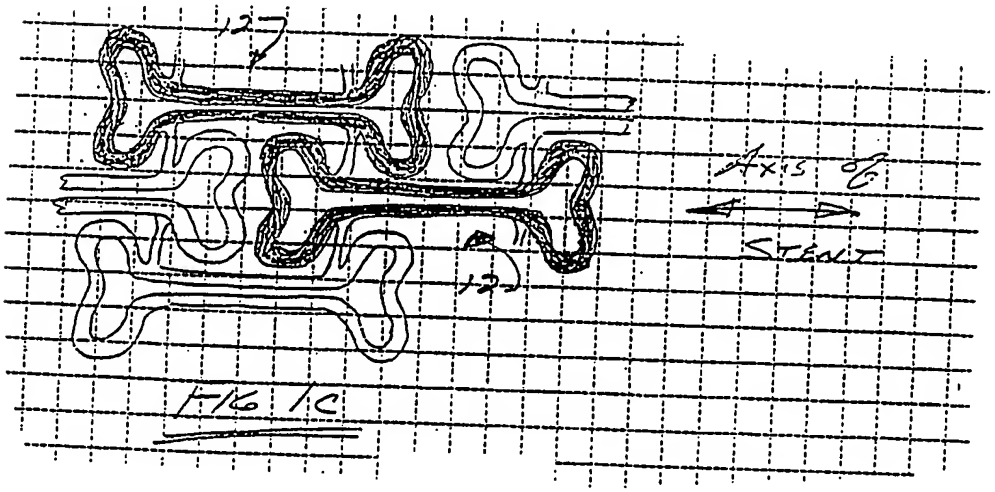


FIG 1c

Fig. 5

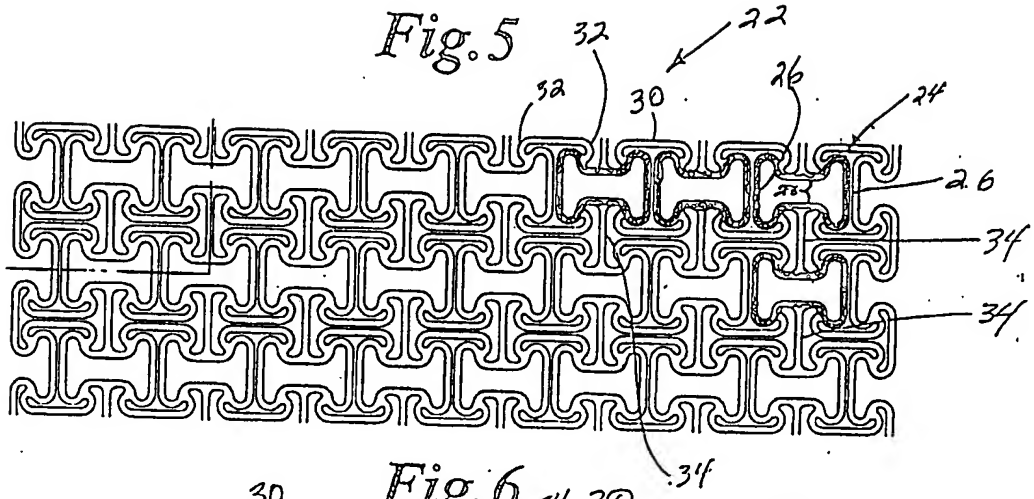


Fig. 6

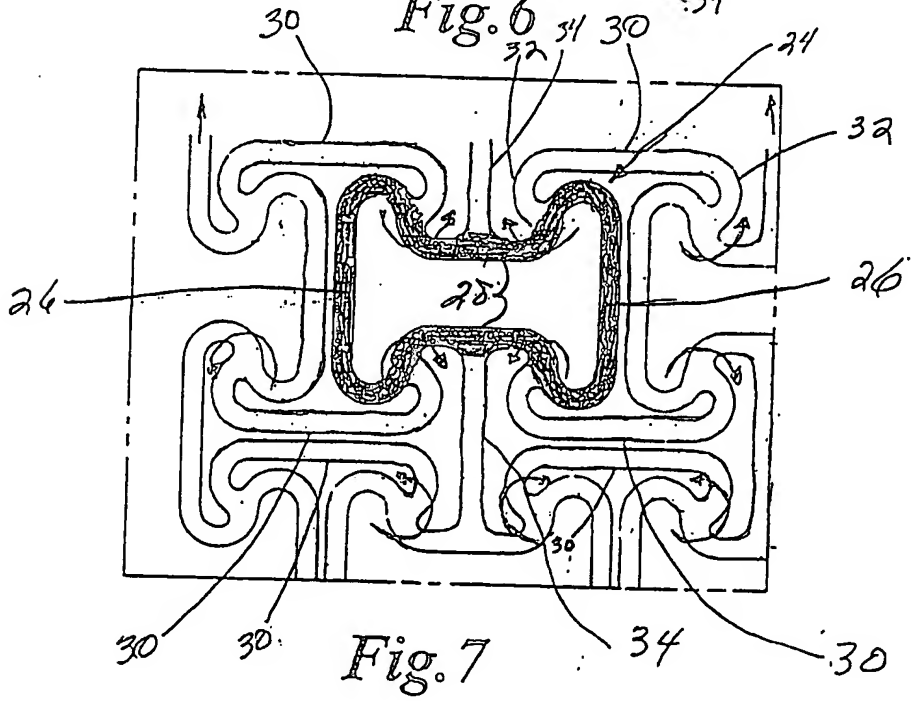


Fig. 7

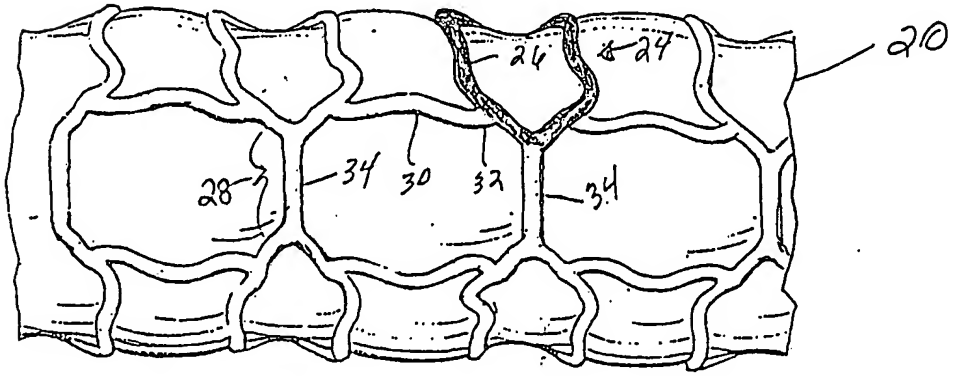


Fig.8

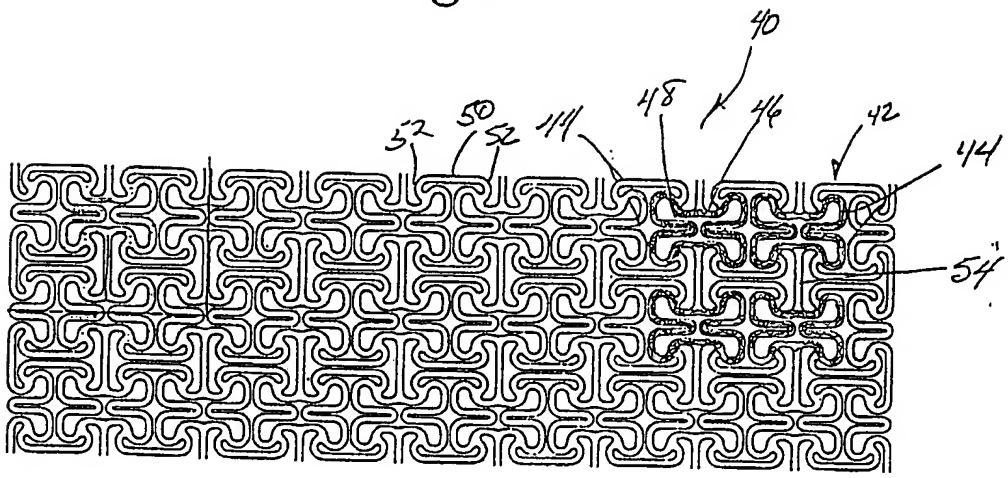


Fig.9

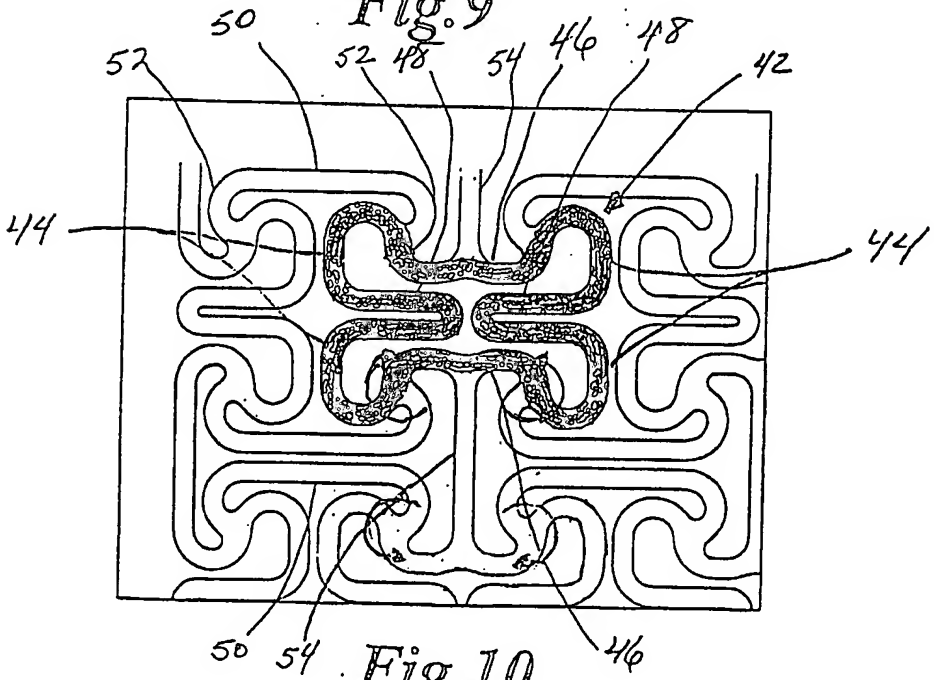
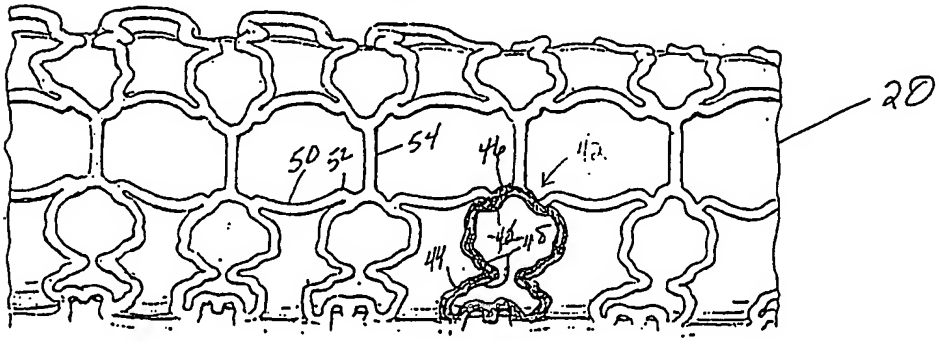


Fig.10



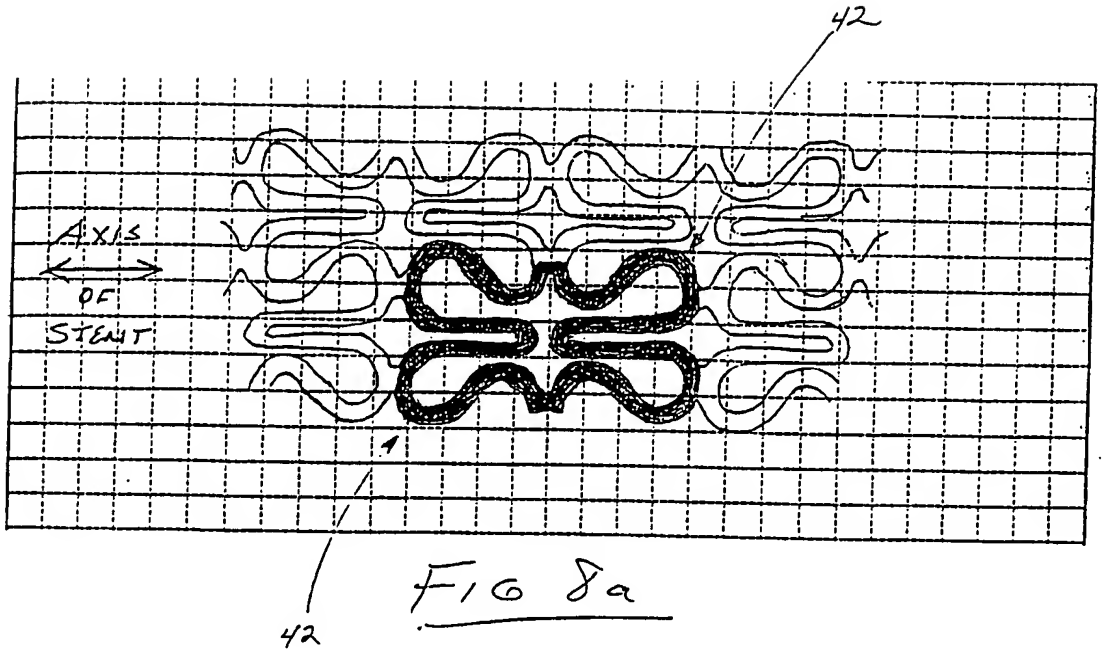


FIG 8a

Fig.11

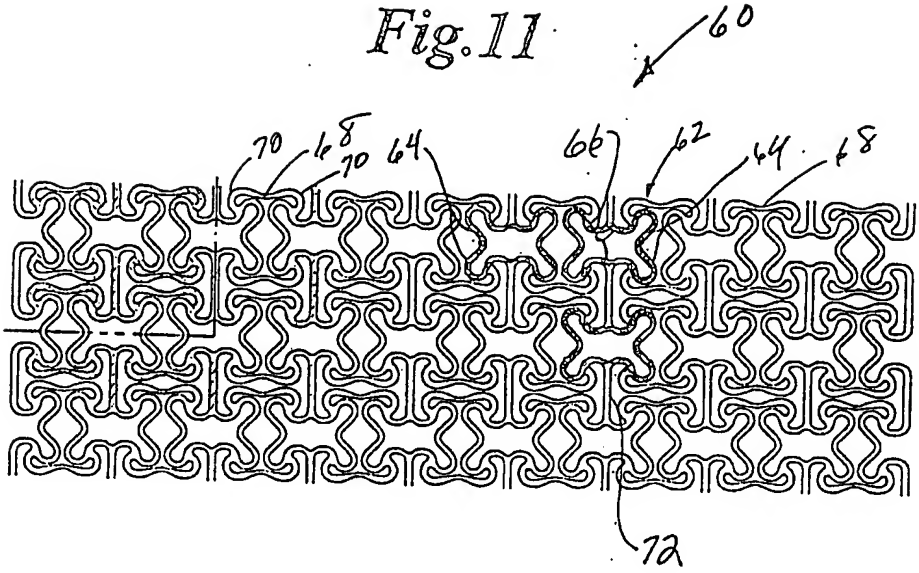


Fig.12

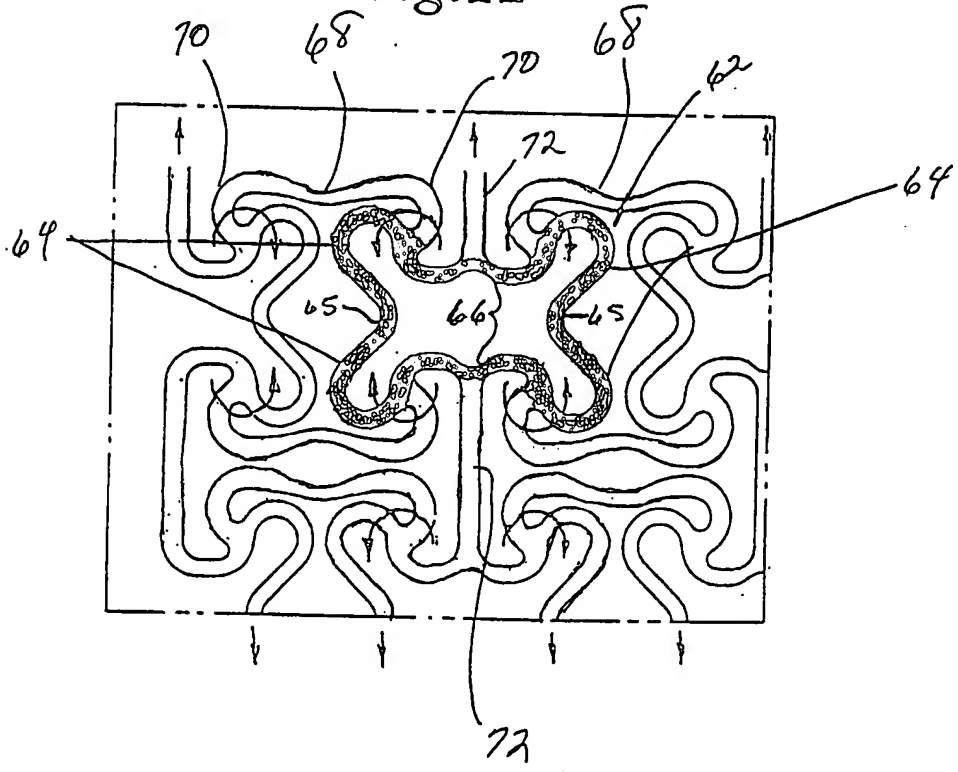


Fig.13

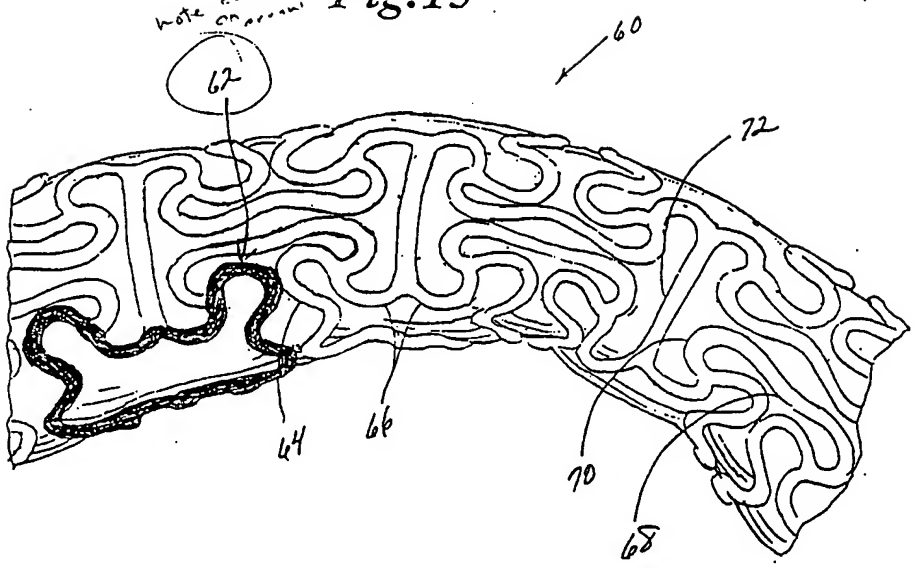


Fig.14

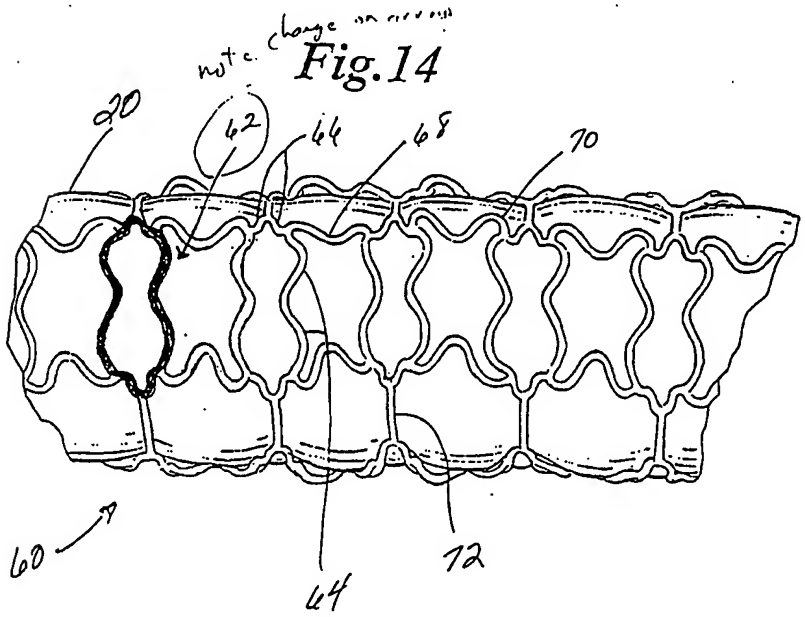


Fig.15

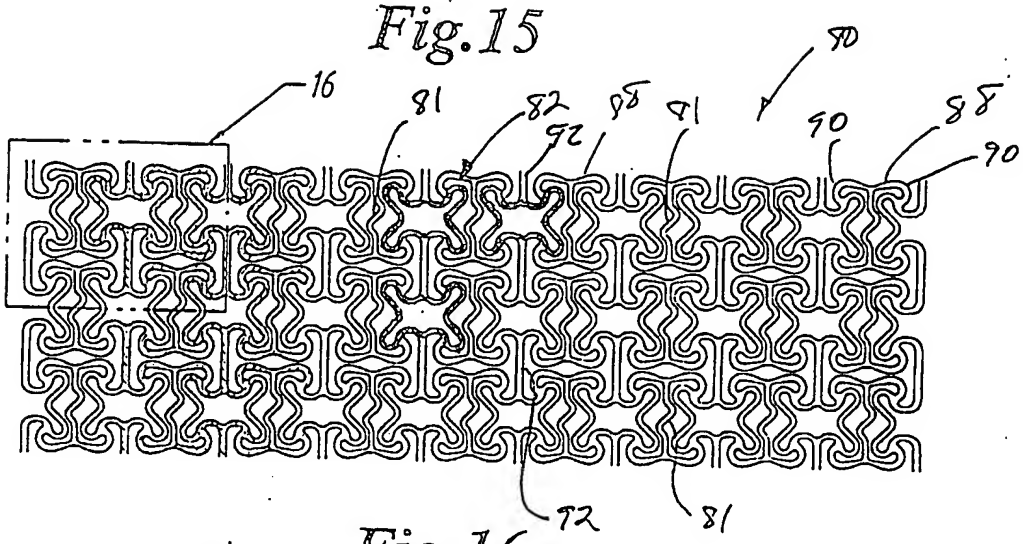

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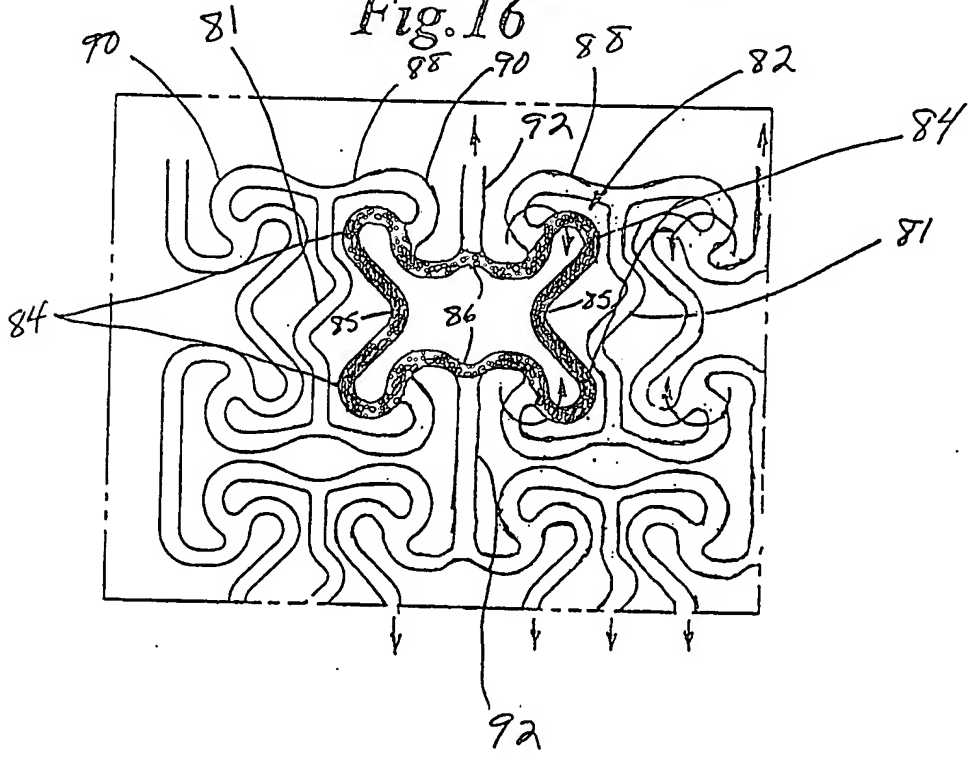
Fig.16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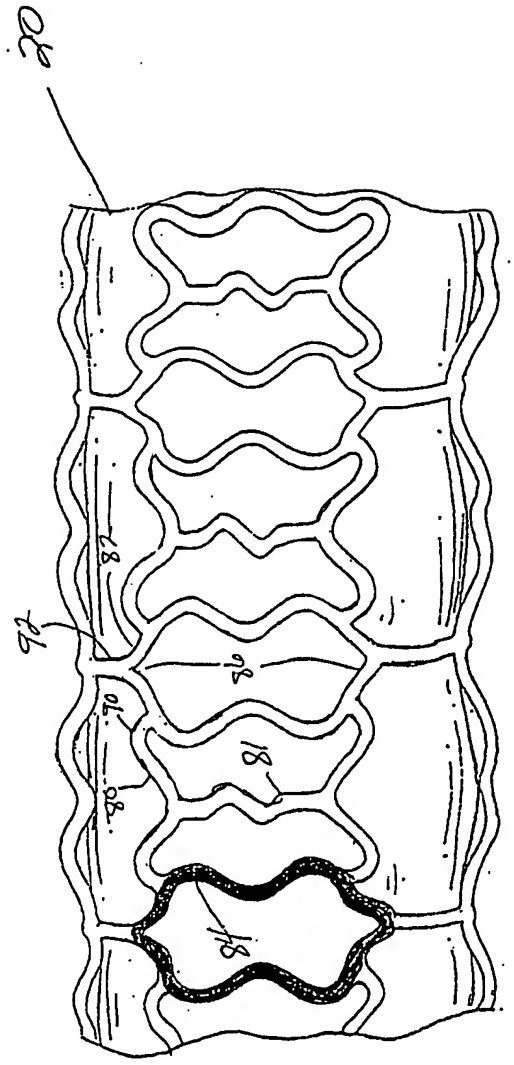


Fig. 17

Fig.18

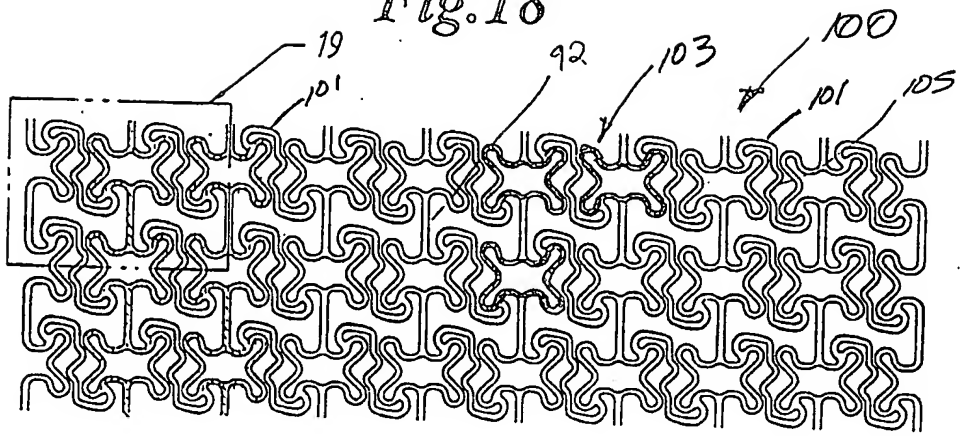
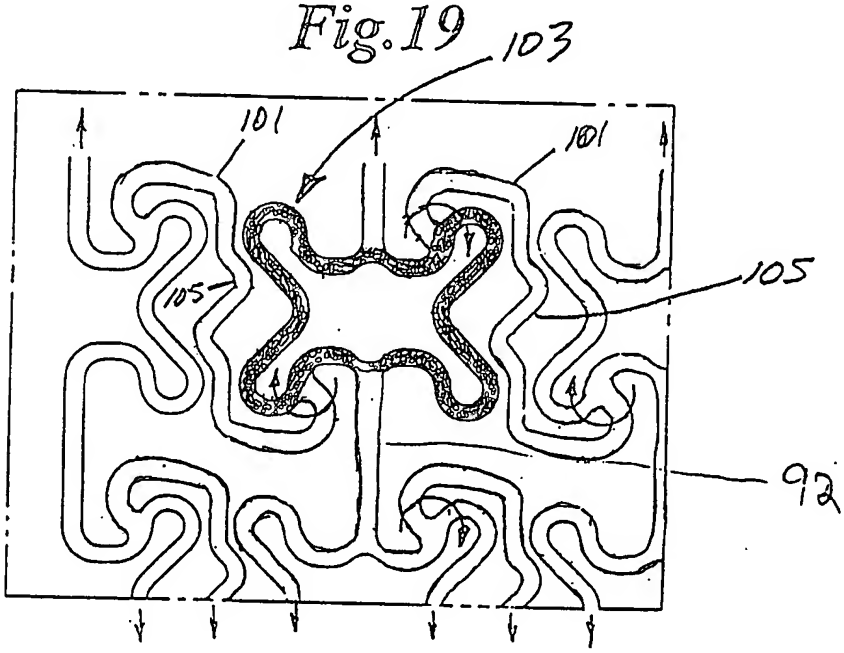


Fig.19



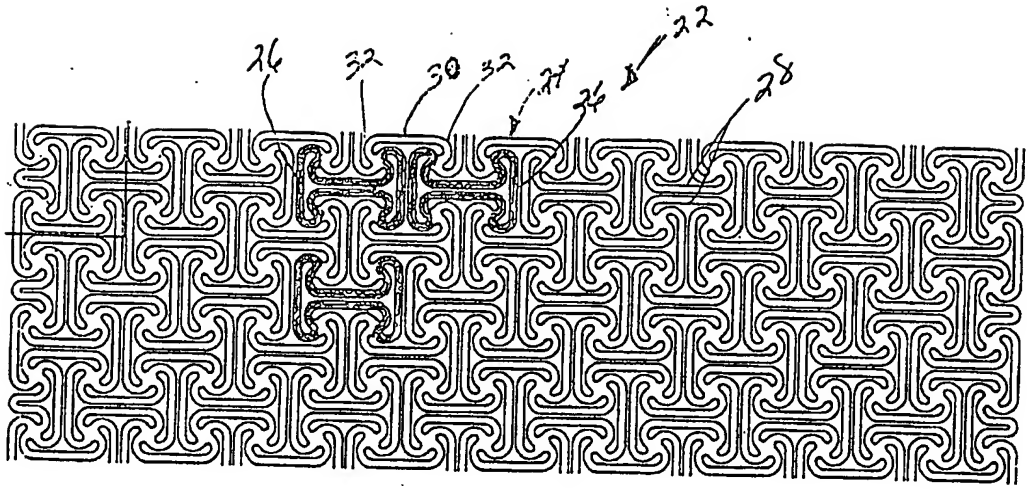


Fig 2B.

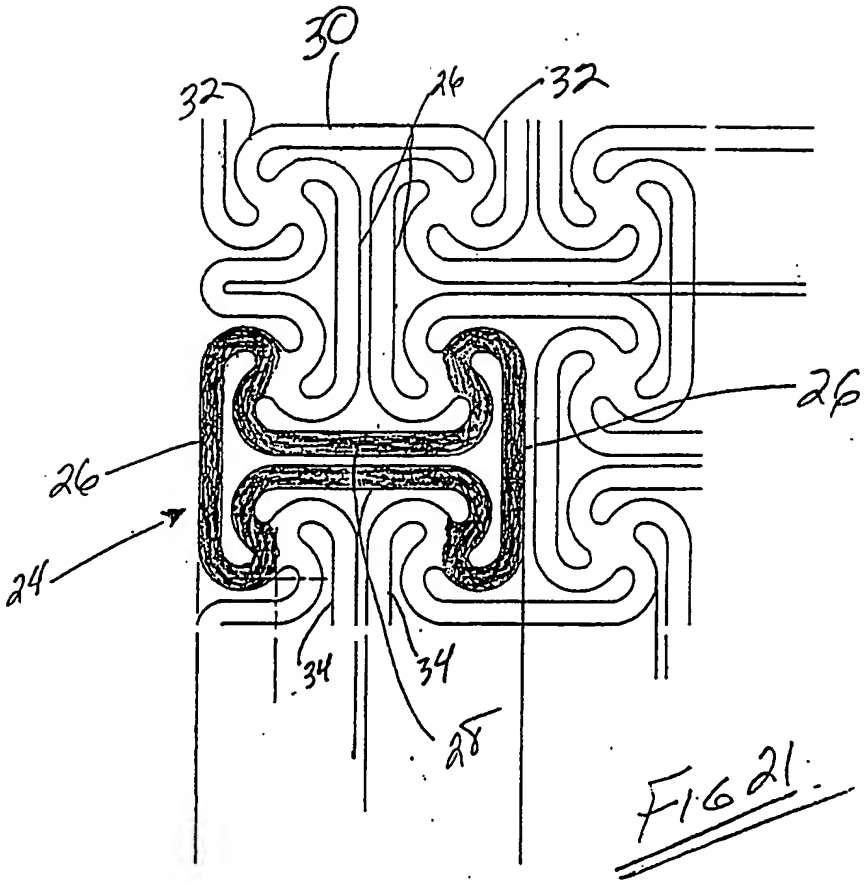


Fig 21

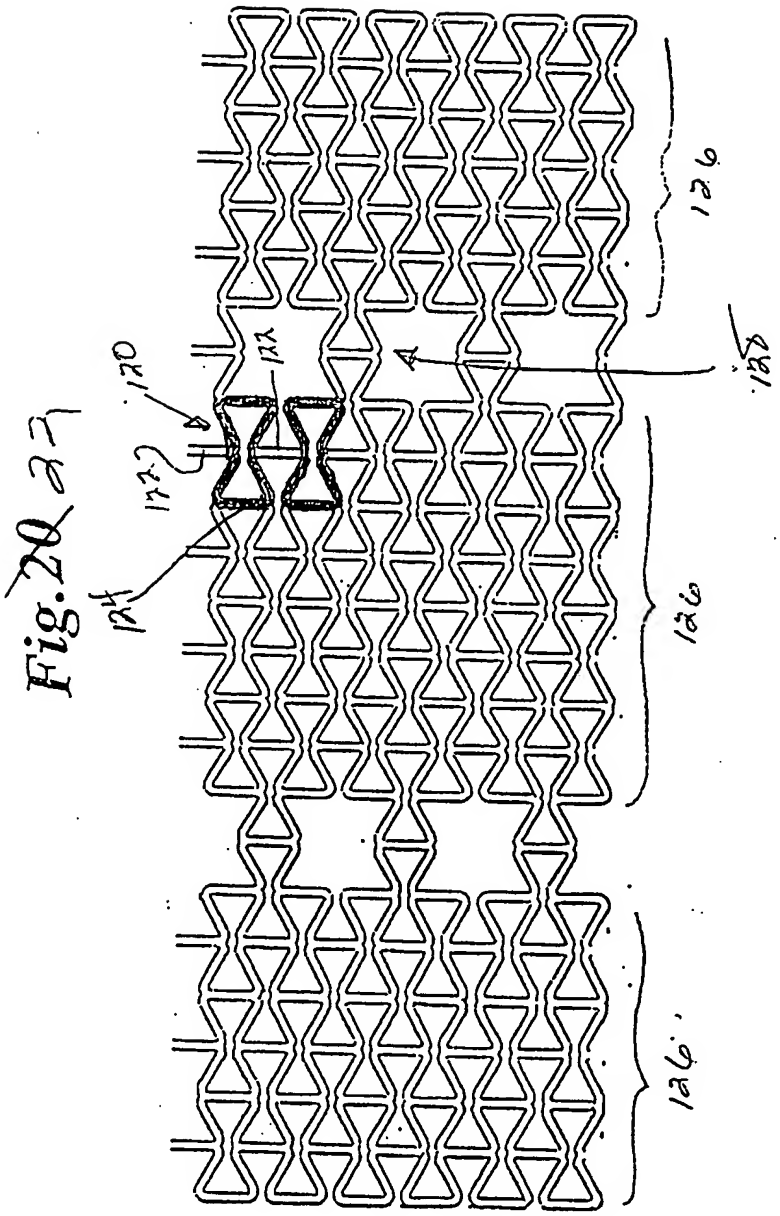


Fig. 2a